

REMARKS

In the Office action of November 16, 2009, claims 17 and 25 were objected to, but were indicated as allowable if rewritten to include the limitation of the claims from which they depended, and such indication of allowable subject matter is greatly appreciated.

Claims 17 and 25 have now been amended to become independent claims and the claims have been edited slightly for a better reading than if the claims were simply combined with the claims from which they depended.

Therefore, an indication of allowance of claims 17 and 25 in the next action is respectfully requested.

In the Office action dated November 16, 2009, claims 15, 18-20, 22, 23, 26-28, 31 and 32 were rejected under 35 U.S.C.102 (e) as being anticipated by Wang et al. (U.S. PG Pub No. 2008/0163688A1).

In addition, in the Office action dated November 16, 2009, claims 16 and 24 were rejected under 35 U.S.C.103 (a) as being unpatentable over Wang et al. in view of Ohtsuka et al. (U.S. PG Pub No. 2003/0075697A1).

In addition, in the Office action dated November 16, 2009, claims 21, 29 and 30 were rejected under 35 U.S.C.103 (a) as being unpatentable over Wang et al. in view of Jorgenson et al. (U.S. PG Pub No. 2006/0192955A1).

In response to the Examiner's rejection, Applicant has amended the claims for a better understanding and Applicant hereby submit the following remarks for the purposes of explaining the differences between the cited references and the present invention as claimed herein.

Support for amendment

The support for currently amended claims 15 and 23 can be found in paragraphs 0052, 0053 and 0055 of the original specification.

Claim 16 has been canceled herein. Claim 15 has been amended to add "wherein said optical waveguide path is an optical waveguide layer which has a clad portion and a core, said core being made of a higher refractive index medium than said clad portion, both said core and said clad portion being stacked on said crystal oscillator," as recited in Claim 16.

Similarly, claim 24 has been canceled herein. Claim 23 has been amended to add "wherein said optical waveguide path is an optical waveguide layer which has a clad portion and a core, said core being made of

a higher refractive index medium than said clad portion, both said core and said clad portion being stacked on said crystal oscillator” as recited in Claim 24.

The support for currently amended claims 17 and 25 can be found in paragraphs 0063, 0064 and 0066 of the original specification.

The support for currently amended claims 18 and 26 can be found in paragraphs 0065 and 0066 of the original specification.

The support for currently amended claims 19 and 27 can be found in paragraph 0067 of the original specification.

The support for currently amended claims 20 and 28 can be found in paragraphs 0075 and 0076 of the original specification.

The support for currently amended claims 21 and 29 can be found in paragraphs 0071 and 0072 of the original specification.

The support for currently amended claims 22 and 30 can be found in paragraphs 0059 and 0070 of the original specification.

The support for new claims 33 and 34 can be found in paragraph 0075 of the original specification.

The support for new claims 35 and 36 can be found in paragraph 0066 of the original specification.

The support for new claims 37 and 38 can be found in paragraphs 0067 to 0069 of the original specification.

It is respectfully submitted that new claims 33 to 44 recite the subject matter which is neither taught nor suggested by the cited references of prior art.

Claims 31 and 32 has been canceled herein.

Comparison of the present invention with each of cited references

The cited references include the following:

D1 : U.S. PG Pub No. 2008/0163688A1 (Wang et al.)

D2 : U.S. PG Pub No. 2003/0075697A1 (Ohtsuka et al.)

D3 : U.S. PG Pub No. 2006/0192955A1 (Jorgenson et al.)

The present invention is a substance adsorption detection method

and a sensor utilizing amounts of change in the optical characteristic of a sensitive thin film with respect to the adsorbed amount of a substance to be detected.

According to the method of Wang et al. (D1), since the ATR coupler (prism) (see Wang paragraph 0059) is designed to be mounted on the face of the crystal substrate, it requires that the air gap between the prism and the crystal substrate is filled with the refractive index matching medium (liquid). When this refractive index matching medium has an increased viscosity, then it has the drawback that Q-value in QCM drops (see Wang paragraph 0123), that is, the sensitivity of the crystal oscillator decreases. Since the present invention discloses the structure such that the optical waveguide is provided on the face of the crystal substrate or the crystal substrate itself serves as the optical waveguide, the prism according to the structure of Wang (D1) is not necessary and it is possible to make the design of the sensor member extremely compact. Further, the present invention provides the solution to the problem that the Q-value in QCM drops according to the method of Wang (D1) since the refractive index matching medium is not necessary.

According to the measurement method of Wang et al. (D1), the method cannot measure a target solution for the reason that the solution does not meet the condition for total internal reflection if the refractive index of the target solution is not lower than that of the crystal. For example, the refractive index of the crystal is about 1.55 though depending on the incident angle of light. Therefore, according to the method of Wang, neither the quinoline solution (refractive index 1.6293) nor the liquid carbon disulfide (refractive index 1.6319) meets the condition for total internal reflection. In addition, according to the method of Wang, it is difficult to measure the toluene or the benzene or the like (refractive index about 1.5) that is close to the refractive index of the crystal, since the incident angle of light due to the total internal reflection must be large. In contrast to this case, according to the method of the present invention, the material (for example, the alumina (refractive index 1.76), ITO (refractive index about 2.1), TiO₂ (refractive index 2.5 to 2.7) or the like) that is larger in the refractive index than that of

the crystal is employed for the core of the optical waveguide and the light enters the end face, or the light enters the core by using the prism positioned at the end portion of the core, and thus these solvent can be measured easily.

Wang et al. (D1) discloses the method that measures illuminated light beam characteristic having total internal reflection at only one reflection point. In contrast to this case, the present invention discloses the unique method that “the method measures light transmitted on said optical waveguide path through said core while the light is repeatedly reflected in said core, said light being emitted through said light emitting means.” Therefore, the method measures the light subjected to the light absorption while the light is repeatedly reflected through the core of the optical waveguide, and thus the light absorption increases and makes it possible to measure the optical characteristic sensitively.

As for claims 15 and 23 in the present invention, Wang et al. (D1) discloses the method in which the prism for entering and emitting light is disposed on the one face of the crystal substrate as shown in Fig.7 and the optical waveguide is disposed on the other face of the crystal substrate opposite to the prism side. Therefore, Wang et al. (D1) cannot easily arrive to the unique structure according to the present invention such that the light inputting means and the light emitting means are disposed on the end faces of core in the waveguide substrate comprising the cladding layer and the core. As the preferred embodiment of the present invention, the light inputting means and the light emitting means are the method such that the prism at the end portion is disposed on the waveguide so as not to have an influence on the oscillation of QCM (Quartz Crystal Microbalance), and as another embodiment of the present invention, the light inputting means and the light emitting means are the method of “butt-coupling”, for example, using the optical fiber, close to the end faces in the waveguide substrate.

In addition, claims 15 and 23 according to the present invention has been amended to incorporate the limitations of the original claims 16 and 24, respectively. Furthermore, the Examiner asserts that “the optical waveguide comprising the core and the cladding layer is provided on the one face of the crystal substrate” by combining “the core of the waveguide is stacked on the

one face of the crystal substrate” as disclosed in Wang et al.(D1) with “the waveguide has the cladding layer which are used to surround the core of the waveguide in order to provide the total internal reflection” as disclosed in Ohtsuka et al.(D2), would have been obvious to the person skilled in the art.

When combining the cladding layer disclosed in Ohtsuka (D2) and the structure disclosed in Wang (D1), the arrangement of the sensor seems to be provided in the order of, prism / the refractive index matching medium / electrode / crystal / electrode / cladding 1 / core / cladding 2. But, in the above structure of Wang(D1), the light is input in the waveguide through the prism and the crystal and the cladding 1, so that the cladding 1 in the waveguide cannot provide confinement of light at the interface between the cladding 1 and the core. That is, it needs to input the light at the angle greater than or equal to the critical angle from the core (the higher refractive index medium) side for guiding the light in the core, but cannot meet this in the above-mentioned case.

Moreover, the clad portion 2 is unsuitable for the adsorption detection of the substance which uses the characteristic of the waveguided light due to the weakening of the evanescent wave from the core (according to the claims 15 and 23 of the present invention, the clad portion 2 is not provided.). Therefore, it cannot usually arrive at the idea that the cladding layer disclosed in Ohtsuka (D2) is applied to the structure of the Wang (D1). In addition, it cannot be easy to arrive at the present invention. In contrast to this case, the structure according to the present invention based on the idea that the input light does not pass through the crystal substrate, is that light enters a core of “an optical waveguide path stacked on a clad portion disposed on the crystal electrode and the core disposed on said clad portion wherein said core is made of a higher refractive index medium than said clad portion”, through the prism disposed on the end face or the end portion in the waveguide. This structure is the possible arrangement due to great difference from the method in which the input light is input in the waveguide from the prism through the crystal substrate according to Wang (D1) and cannot be configured by merely a simple modification according to the method of Wang (D1).

In addition, Wang et al. (D1) discloses the method that observes the state of attenuation of the reflected light when the waveguide according to

Wang meets the condition for guiding, but Wang et al. (D1) does not disclose the method that observes the guided light in the waveguide according to Wang. Therefore, the method according to Wang et al. (D1) is greatly different from the method according to the present invention in that "it inputs light through said light inputting means to said core of the optical waveguide path, and measures light transmitted on said optical waveguide path through said core while the light is repeatedly reflected in said core, said light being emitted through said light emitting means." as recited in claim 15.

In contrast to currently amended claims 15 and 23, Wang (D1) in view of Ohtsuka (D2) neither teaches nor suggests the method and sensor according to the present invention.

As for claims 17, 18, 25 and 26 in the present invention, Wang et al. (D1) discloses the sensor for simultaneously performing the QCM (Quartz Crystal Microbalance) and SPR (Surface Plasmon Resonance) sensing in Fig.3. (See Wang paragraphs 0088 and 0091). This is shown in Fig.3 of Wang (D1) in which the light entered into the prism is certainly passed through the crystal substrate. But Wang does not disclose the structure that allows the crystal substrate to function as the core of the waveguide. Since the light does not repeat the total internal reflection in the crystal substrate according to Wang (D1) and thus the crystal substrate cannot provide confinement of light to guide, the crystal substrate is not appreciated as suggesting the "waveguide", and is merely the medium which transmits the light (having a refractive index). Therefore, Wang et al. (D1) cannot easily arrive to the unique structure according to the present invention such that it allows the light to enter the prism disposed on the end faces or the end portions in the crystal substrate and then allows the light to reflect many times in the crystal substrate, and such that it repeats the total internal reflection in the crystal substrate and thus the sensitivity of the crystal oscillator increases. In the meantime, an electrically conductive transparent film on the crystal according to claims 18 and 26 in the present invention functions as an electrode and a clad portion, and thus the structure thereof is unsuitable for the adsorption detection of the substance using the characteristic of the waveguided light due to the weakening of the evanescent wave from the core.

But, since the crystal substrate according to claims 18 and 26 in the present invention functions as the core and light is easy to guide, the high intensity light emitting is acquired from the waveguide and thus the device fabrication and its measurement can have the advantage to facilitate.

Wang (D1) neither teaches nor suggests the subject matter recited in the currently amended claims 17, 18, 25 and 26.

As for claims 19, 27, 35, 36, 37 and 38 in the present invention, Wang et al.(D1) discloses the structure in which the metallic thin film electrodes is formed on upper and lower face of the crystal substrate. (See Wang paragraph 0121.) But since the light does not repeat the total internal reflection in the crystal substrate according to Wang (D1) and thus the crystal substrate does not provide confinement of light to guide (no equivalent to the core and the clad portion), the crystal substrate does not appreciate to suggest the "waveguide". Wang (D1) neither teaches nor suggests the unique structure according to the present invention such that the metallic film is formed on the optical waveguide and that the thin film on which a detection target substance is adsorbed is further provided on said metallic film and that light enters the prism positioned at the end face or the end portion of the core and thus the surface plasmon can be excited on the surface of the metallic film.

Wang (D1) neither teaches nor suggests the subject matter recited in the currently amended claims 19, 27, 35, 36, 37 and 38.

As for claims 20 and 28 in the present invention, Wang (D1) discloses a substance adsorption detection method and its sensor that measures a surface acoustic wave characteristic of a piezoelectric element and light which passes through the optical path on or in the piezoelectric element. But, the method according to Wang (D1) is not equivalent to the core and the clad portion. Therefore, Wang (D1) cannot easily arrive to the unique structure according to the present invention such that the light is repeatedly reflected in the piezoelectric element and provide confinement of light and thus guide and increase the sensitivity of the sensor.

As for claims 15, 17, 18, 22, 23, 25, 26, 30, 33 and 34 in the present invention, while Wang et al. (D1) is limited to the combined method of the QCM (Quartz Crystal Microbalance) and SPR (Surface Plasmon Resonance) sensing, the method of the present application can sense simultaneously not only the QCM and SPR but also the QCM and the optical waveguide spectrometry. (See paragraph 0055 in the specification of the present application).

In addition, the method of the optical waveguide spectrometry according to the present invention can measure the optical absorption spectrum of the adsorbed-substance directly by inputting the white light. Since the method using the SPR by the metallic thin film according to Wang (D1) observes the absorption of the metallic thin film and the absorption based on the surface plasmon excitation, it cannot observe the optical absorption spectrum of deposited medium directly.

As for claims 19, 22, 27 and 30, it is strongly believed that they are also all allowable, since they depend on the above independent claims 15, 17, 18, 23, 25 and 26.

In addition, as for new claims 33 and 34, it is strongly believed that they are also all allowable, since they depend on the above independent claims 20 and 28.

In addition, as for new claims 37 and 38, it is strongly believed that they are also all allowable, since they depend on the above independent claims 35 and 36.

As for claims 21 and 29 in the present invention, the local plasmon is based on resonant oscillation of free electrons of the metallic particles relative to the electric-field of irradiated light, under such condition that the minimal metallic particles exist decentrally. This resonance can be utilized as the adsorption measurement because of dependence on the refractive index and thickness of the medium in the vicinity of the metallic colloid. Specifically, the optical change is measured because of light absorption occurring when resonating. Therefore, though the thin gold film as disclosed in Wang can be exchanged with the gold colloid layer as disclosed in Jorgenson et al.(D3), the structure and method combining Wang (D1) and

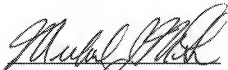
Jorgenson (D3) neither disclose nor suggest the unique structure and method according to the present invention such that "it forms a metallic colloid layer on at least one of a crystal oscillator and a surface acoustic wave element, said crystal oscillator comprising a crystal and electrodes formed on either face of said crystal, and inputs light downward to said metallic colloid layer while a detection target substance adsorbs on said metallic colloid layer, and measures an adsorbed mass with at least one of said crystal oscillator and said surface acoustic wave element, and measures an optical characteristic of said metallic colloid layer." as recited in claims 21 and 29 of the present invention.

CONCLUSION

In view of the amendment and remarks, reconsideration of the application is respectfully requested. Claims 15, 17-23, 25-30 and 33-44 are now pending and a Notice of Allowance for these claims is earnestly solicited.

Respectfully submitted,

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